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SMALL MAMMAL POPULATIONS after a WILDFIRE in NORTHEAST MINNESOTA

RICHARD R. BUECH, KARL SIDERITS, ROBERT E. RADTKE
EDWARD L. SHELDON, AND DONALD ELSING

NORTH CENTRAL FOREST EXPERIMENT STATION
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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North Central Forest Experiment Station
John H. Ohman, Director
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108

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SMALL MAMMAL POPULATIONS AFTER A WILDFIRE IN NORTHEAST MINNESOTA

Richard R. Buech, *Wildlife Biologist*
North Central Forest Experiment Station, St. Paul, Minnesota

Karl Siderits, *Forest Biologist*
Superior National Forest, Duluth, Minnesota

Robert E. Radtke, *Wildlife Biologist*
Eastern Region, Forest Service, USDA, Milwaukee, Wisconsin

Howard L. Sheldon, *Forest Biologist*
Chequamegon National Forest, Park Falls, Wisconsin

and **Donald Elsing,** *Forest Biologist*
Superior National Forest, Duluth, Minnesota

Many studies have been done on small mammal populations following both wildfires and prescribed burns but only one, that of Krefting and Ahlgren (1974), pertains to wildfire in a forest community typical of northern Minnesota. The Roy Lake Fire provided an excellent opportunity to study the impact of extensive and severe wildfires on small mammal populations. This 1,368 ha fire occurred within the Boundary Waters Canoe Area of the Superior National Forest in the northwest tip of Cook County in northeast Minnesota in late August 1976. The study was limited to the most severely burned portions.

METHODS

Small mammal populations were assessed in three community types: aspen-fir-spruce, jack pine, and black spruce-jack pine. For each community (except the black spruce-jack pine), two areas were chosen for data collection—one severely burned during the Roy Lake Fire and the other a comparable control area outside the fire perimeter. A control area was not available for the black spruce-jack pine community, but because of similarities in understory composition, the jack pine control area was used for both the jack pine and black spruce-jack pine burn areas. Two small mammal assessment lines, spaced 120 m apart, were centrally located within each area. Each assessment line consisted of 25 stations spaced 15 m apart, with 2 snap traps located at each station. Where it was not possible to maintain a straight line and still remain within severely burned portions, the lines were 'dog-legged' in the cardinal direction away from the other assessment line.

The snap traps, 100 on each of the 5 areas, were baited with peanut butter on August 31, 1976. Traps were checked September 1 and 2, 1976, in the black spruce-jack pine burn area (total trapping effort equalled 100 trap station nights) and September 1, 2, and 3, 1976, in the other four areas (total trapping effort in each equalled 150 trap station nights). The traps were removed on the last day. The following information was recorded for each capture: species; capture location; weight; total length and length of the tail, hindfoot, and ear; sex, testes position, and size of nipples. Individuals were subsequently assigned to one of three age classes on the basis of body weight as defined by Buech (1974) (table 1).

Unless otherwise indicated, capture indices (C.I.) are based on the number of captures/1,000 trap station nights. A trap station night consisted of two traps set at a station for 24 hours.

Table 1.—*The weight-class limits used to define age class for three species*

(In grams)

Species	Juvenile	Subadult	Adult
Southern red-backed vole (*Clethrionomys gapperi*)	<14	14 to 19	>19
Deer mouse (*Peromyscus maniculatus*)	<16	16 to 21	>21
Masked shrew (*Sorex cinereus*)	< 2.5	2.5 to 3.9	> 3.9

RESULTS
Species Captured

On all areas combined, a total of 313 individuals were captured during 700 trap station nights (table 2). The five species that were caught, in decreasing order were: the southern red-backed vole (*Clethrionomys gapperi*), deer mouse (*Peromyscus maniculatus gracilis*), masked shrew (*Sorex cinerius*), rock vole (*Mecrotus chrotorrhinus*), and least chipmunk (*Eutamias minimus*). Red-backed voles were captured on all areas, deer mice and masked shrews on both burn and control areas in the aspen-fir-spruce and jack pine communities, rock voles on the aspen-fir-spruce control, and least chipmunks on the aspen-fir-spruce and jack pine control areas. None of the captured individuals showed any sign of fire-related injury.

Capture Indices

The highest capture index (C.I.) for each species was 900 for the red-backed vole, 240 for the deer mouse, 47 for the masked shrew, 27 for the rock vole, and 7 for the least chipmunk. The highest index for all species combined was 1,207 in the aspen-fir-spruce control area, followed by 580 in the jack pine control. The dominant species in both the aspen-fir-spruce and jack pine control areas was the red-backed vole. The deer mouse was also abundant in the aspen-fir-spruce control but was not abundant in the jack pine control. Other species in the aspen-fir-spruce and jack pine control areas were comparatively low. In general, the aspen-fir-spruce community supported the highest number and diversity of small mammals, followed by the jack pine and black spruce-jack pine communities.

In the aspen-fir-spruce and jack pine communities combined, the number of individuals of all species captured in burned areas averaged 16 percent of that in control areas—13 percent for the red-backed vole, 25 percent for the deer mouse, and 33 percent for the masked shrew. By community type, this percentage was highest for red-backed voles and masked shrews in aspen-fir-spruce community, and for deer mice in the jack pine community. In fact, in the jack pine community, the number of deer mice captured in the burned area exceeded that captured in the control.

Table 2.—*Small mammal populations in burned and control communities of three different types on the Roy Lake Fire expressed by capture index (C.I. = captures/1,000 trap station nights)*

Species	Total captures	Community type: Aspen-fir-spruce			Jack pine			Black spruce-jack pine		Aspen-fir-spruce plus jack pine
		Burn	Control	Burn control	Burn	Control	Burn control	Burn	Burn[1] Jack pine control	Burn control
		C.I.	C.I.	*Percent*	C.I.	C.I.	*Percent*	C.I.	*Percent*	*Percent*
Red-backed vole	241	147	900	16	40	500	8	20	4	13
Deer mouse	50	20	240	8	47	27	175	-	-	25
Masked shrew	16	13	33	40	13	47	29	-	-	33
Rock vole	4	-	27	0	-	-	-	-	-	0
Least chipmunk	2	-	7	0	-	7	0	-	-	0
TOTAL	313	180	1207	15	100	580	17	20	4	16

[1]A control was not obtained, but due to similarities in the understory, values from the jack pine control were used for comparison.

Age Class Distribution

Age class distribution, mean body weight, sex ratio, and reproductive data all provide useful information for interpreting the source of populations on burned areas, i.e., were individuals prefire residents, postfire immigrants, or a combination of both? For all community types combined, the age class distribution of the red-backed vole and masked shrew was similar between burned and control areas (table 3). For red-backed voles, subadults and adults codominated the age class distribution and juveniles were few. For masked shrews, all but one capture were subadults. However, for deer mice, no adults were captured, and although juveniles and subadults were equal on both control areas combined, juveniles predominated on the burned areas.

Mean Body Weight

For red-backed voles and deer mice the mean body weight of individuals captured on the burn and control areas was similar (table 4). Although mean weight for all types combined was slightly less on burned areas for both species, it was not significant.

Sex Ratio

Where sample size was adequate, a chi-squared test was used to detect differences from an expected 50:50 sex ratio and also between the burned and control areas by assuming that the ratio observed on burned areas would be similar to their controls. The data for all communities combined indicates that there were nearly equal numbers of red-backed vole males and females on burned areas, but there was a significant preponderance of females on control areas. In contrast, male deer mice were more abundant on burned areas, while the male to female ratio was nearly equal on control areas (table 5). The data comparing the sex ratio observed in the burned area with that of its respective control was adequate only for red-backed voles. These data indicate that for all types combined, the sex ratio observed on burned areas was not significantly different from that observed on control areas.

Reproduction

Males were considered reproductively active if they had scrotal or ascending testes and females if they had medium or large nipples. The red-backed vole was the only species that showed evidence of

Table 3.—*Age class distribution on burned and control areas of three community types*

Community type	Area	Age class							
		Juvenile		Subadult		Adult		Unknown	
		Captures	Total captures	Captures	Total captures	Captures	Total captures	Captures	Total captures
		Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
		Red-backed vole							
Aspen-fir spruce	Burn	1	5	11	50	10	45	-	-
	Control	9	7	58	43	63	47	5	4
Jack pine	Burn	1	17	3	50	2	33	-	-
	Control	4	5	43	57	28	37	-	-
Black spruce-jack pine	Burn	-	-	1	33	2	67	-	-
	Control[1]	-	5	-	57	-	37	-	-
Total all types	Burn	2	6	15	48	14	45	-	-
	Control	13	6	101	48	91	43	5	2
		Deer mouse							
Aspen-fir spruce	Burn	3	100	-	-	-	-	-	-
	Control	17	47	19	53	-	-	-	-
Jack pine	Burn	5	71	2	29	-	-	-	-
	Control	3	75	1	25	-	-	-	-
Total all types	Burn	8	80	2	20	-	-	-	-
	Control	20	50	20	50	-	-	-	-
		Masked shrew							
Aspen-fir spruce	Burn	-	-	2	100	-	-	-	-
	Control	-	-	4	80	1	20	-	-
Jack pine	Burn	-	-	1	50	-	-	1	50
	Control	-	-	7	100	-	-	-	-
Total all types	Burn	-	-	3	75	-	-	1	25
	Control	-	-	11	92	1	8	-	-

[1]A control was not obtained, but due to similarities in the understory, values from the jack pine control were used for comparison.

Table 4.—*Mean body weight of the red-backed vole and deer mouse by community type and area*

Community type	Area	Red-backed vole			Deer mouse		
		Observations	Mean body weight	Standard error	Observations	Mean body weight	Standard error
		Number	*Grams*		*Number*	*Grams*	
Aspen-fir-spruce	Burn	22	19.4	0.9	3	14.7	0.3
	Control	112	20.8	0.5	28	15.9	0.3
Jack pine	Burn	6	17.7	1.0	7	15.4	0.8
	Control	73	20.0	0.7	4	15.1	0.8
Black spruce-jack pine	Burn	3	20.9	1.8			
	Control[1]	73	20.0	0.7			
All types combined	Burn	31	19.2	0.7	10	15.2	0.5
	Control	185	20.5	0.4	32	15.8	0.3

[1]A control was not obtained, but due to similarities in the understory, values from the jack pine control were used for comparison.

Table 5.—*Sex ratios of the red-backed vole and deer mouse on burned and control areas of three community types. A chi-squared test was used to compare the sex ratio with an expected 50:50 ratio, and the ratio on the burn with its respective control*

Community type	Area	Male	Female	Unknown sex	Total	Male	x^2 50:50 Ratio	P	x^2 Burn: Control	P
		Number				*Percent*				
		Red-backed vole								
Aspen-fir-spruce	Burn	12	10	0	22	55	-	-	-	-
	Control	46	85	4	135	35	11.611	[3].999		
Jack pine	Burn	2	4	0	6	33	-	-	-	-
	Control	33	41	1	75	45	.865	.648		
Black spruce-jack pine	Burn	1	2	0	3	33	-	-	-	-
	Control[2]	-	-	-	-	45	-	-	-	-
All types combined	Burn	15	16	0	31	48	.032	.143	1.270	.740
	Control	79	126	5	210	39	10.776	[3].999		
		Deer mouse								
Aspen-fir-spruce	Burn	3	0	0	3	100	-	-	-	-
	Control	19	15	2	36	56	.471	.507		
Jack pine	Burn	4	3	0	7	57	-	-	-	-
	Control	1	3	0	4	25	-	-		
Black spruce-jack pine	Burn	-	-	-	-	-	-	-	-	-
	Control[2]	-	-	-	-	-	--	-		
All types combined	Burn	7	3	0	10	70	-	-	-	-
	Control	20	18	2	40	53	.105	.254		

[1]The proportion of males was based on the total number of individuals for which sex could be determined.
[2]A control was not obtained, but due to similarities in the understory, values from the jack pine control were used for comparison.
[3]Significant at the 0.95 level of probability.

reproductive activity, thus the analysis was restricted to this species. For the aspen-fir-spruce and jack pine communities combined, the number of reproductively active males and females was equal at about one-fourth of the total population and similar between burned and control areas (table 6). The data comparing reproductively active individuals to the adult segment of the population was similar, except it amounted to about one-half of the adult population.

DISCUSSION

Population Characteristics not Related to Fire

The C.I. of 900 for red-backed voles, 240 for deer mice and 47 for masked shrews show that populations were high in control areas. Although methods varied, the highest C.I.'s reported from

other studies in northern Minnesota were either comparable or lower. For example, Beer *et al.* (1973) reported C.I.'s of 19 for red-backed voles, 8 for deer mice, and 5 for masked shrews, during the summer of 1969 in several different forest communities. In mature aspen-birch communities, Beer (unpublished data) found that for a period of 21 years, C.I.'s (per 1,000 trap nights) for red-backed voles ranged from 3 to 37 with an average of 11, and for deer mice they ranged from 16 to 135 with an average of 49. For a 4-year period after the Little Sioux Fire, Buech (unpublished data) obtained C.I.'s (per 1,000 trap nights) up to 243 for red-backed voles and up to 130 for deer mice. For a 4-year period in a mature jack pine stand, Ahlgren (1966) obtained data that indicated C.I.'s of up to 750 for red-backed voles and 350 for deer mice.

Further evidence that red-backed vole populations were high is suggested by the age class distribution. Krebs *et al.* (1969) noted that increasing and peak populations of *Microtus* are characterized by large adults. More than 40 percent of the red-backed voles captured in our study weighed more than 19 grams and 20 percent (8 percent males) weighed more than 25 grams. By comparison, during September in an increasing population of red-backed voles, Buech (1974) found few males more than 19 grams and none more than 25 grams. Thus, for this time of year, the proportion of large-sized adults on the Roy Lake Fire was high. In addition, one half of the adults showed signs of reproductive activity, and although none were pregnant, 7 percent of all captures were females weighing more than 30 grams. Thus, although they were reproductively active in early September, the lack of pregnancies indicates activity would probably cease by the end of September, which is similar to what Buech (1974) found. To summarize, the population of red-backed voles was high and contained many large-sized adults that were still reproductively active. Although breeding was near completion, the number of lactating females suggests that the population would increase when their litters entered the trappable population.

Although C.I.'s indicate that the deer mouse was abundant, there was a curious lack of adult-sized individuals and because none were reproductively active, little further increase would be expected during autumn. In contrast, in September during a population high, Buech (1974) found a large ratio of adult-sized individuals, some of which were still reproductively active.

The diversity and abundance of small mammals on the aspen-fir-spruce control was expected because of the vegetation structure and diversity.

Table 6.—*The number of males with scrotal or ascending testes and the number of females with medium or large nipples on the burned and control areas of three community types for the red-backed vole*

Community type	Area	Males			Females		
		Total	Scrotal testes	Scrotal testes	Total	Medium-large nipples	Medium-large nipples
		Number		*Percent*	*Number*		*Percent*
Aspen-fir-spruce	Burn	12	3	25	10	4	40
	Control	46	8	17	85	18	21
Jack pine	Burn	2	0	0	4	0	0
	Control	33	11	33	41	13	32
Black spruce-jack pine	Burn	1	1	100	2	1	50
	Control[1]			33			32
Aspen-fir-spruce and jack pine Combined (all ages)	Burn	14	3	21	14	4	29
	Control	79	19	24	126	31	25
Aspen-fir-spruce and jack pine combined (adults only)	Burn	4	1	25	7	4	57
	Control	36	17	47	55	31	56

[1]A control was not obtained, but due to similarities in the understory, values from the jack pine control were used for comparison.

Vegetation sampling in the shrub, herbaceous, and moss layers of the aspen-fir-spruce and jack pine control communities indicated major differences in species composition and density.[1] The biomass of shrubs and seedlings in the aspen-fir-spruce control was more than four times the amount in the jack pine control area. Similarly, herbaceous biomass in the aspen-fir-spruce control area was more than three times that in the jack pine control area. However, the jack pine control area supported a moss-lichen layer with twice the biomass of that found in the aspen-fir-spruce control. In both areas, though, the moss-lichen layer was the dominant component, after trees, in total biomass.

During a population low, Beer *et al.* (1973) found that small mammals were uniformly distributed among aspen-birch, birch, jack pine-birch, and jack pine communities. This suggests that the differences we observed between communities may not have existed if populations had been much lower. Data from other studies also suggest that mature jack pine communities are suitable for red-backed voles, although this may be expressed only during population highs (Ahlgren 1966, Sims and Buckner 1973, Krefting and Ahlgren 1974).

The discovery of a population of rock voles is particularly noteworthy. The existence of this species in Minnesota is known from a single specimen taken near Burntside Lake in St. Louis County (Swanson 1945, Handley 1954) and a recent discovery of a population north of Grand Marais along the Gunflint Trail (Timm 1974). Our specimens identify a second recent population in the State (Buech *et al.* 1977).

Impact of Fire on Small Mammal Populations

Studies of small mammal populations following wildfires and prescribed burns have revealed instances in which individuals survived the fire within the confines of the burn (Tevis 1956, Tester 1965, Lawrence 1966), escaped the fire by immigrating to unburned areas (Tevis 1956, Howard *et al.* 1959, Lawrence 1966), or died as a result of fire (Tevis 1956, Chew *et al.* 1959, Tester 1965). The survival of residents staying within the burn itself has been associated with the existence of small inclusions of unburned habitat (Tevis 1956, Lawrence 1966). Data provided by Lawrence (1966) and Howard *et al.* (1959) suggest that the conditional lethal temperature range is about 120 to 145° F, depending on the relative humidity. Other experiments by Lawrence (1966) suggest that animals can survive as long as burrow conditions permit vapor pressures below 40 mm Hg and if their burrows are at least 3 inches below the soil surface. Thus, these studies suggest that survival within the burn is contingent upon the uniformity, intensity, and duration of the burn with survival being greater where the burn is incomplete in fuels of low density and high moisture content.

Survival by emigration to unburned areas has been noted both through direct observation (Tevis 1956, Howard *et al.* 1959) and inference through the results of trapping (Tevis 1956, Lawrence 1966). However, these observations were made in comparatively small prescribed burns. In extensive wildfires, this strategy may be less successful for small mammals as evidenced by the number of carcasses found by Chew *et al.* (1959) in the extensive Malibou burn in southern California. Thus, the importance of emigration to survival of resident small mammals probably depends on the extent of the burn and the forward rate of spread.

The Roy Lake Fire occurred at the end of August during an extreme drought in aspen-birch-conifer communities. The fire was intense and entirely consumed the foliage and fine branches in tree crowns and organic material on the ground down to mineral soil, especially on the slopes and ridge tops. In spite of this, the variable topography permitted some portions to escape burning entirely or to burn only lightly, especially in depressions and lowland areas. This lack of uniformity was probably conducive to the survival of a segment of the prefire resident population of small mammals and to their continued postfire existence on the trapped sites.

The time interval between the end of the burn and the beginning of trapping was a little more

[1] *Siderits, Karl. 1977. Roy Lake Fire biological administrative study. Unpublished report on file at Superior National Forest, Duluth, Minnesota.*

than 1 week. This allowed little time for immigration, especially to interior portions of this large fire. However, it is possible that part of the postfire population was composed of individuals that moved in after the fire, or shifted their location within the burned area. This is suggested by the data for deer mice in the jack pine type, where they were more abundant on the burn than on the control area and where there was some suggestion that males and juveniles were more abundant on burned areas than would be expected. Thus the data may represent not only postfire survival, but may also reflect some other population adjustment factor that operated after the fire. These factor(s) however, did not statistically alter population attributes such as age class distribution, mean body weight, sex ratio, or the number of reproductively active adults from that observed in control populations, especially for red-backed voles. However, our sample size on the burned areas was often too small to detect any statistical difference.

The fire had a significant impact on the small mammal population, reducing it to an average of 16 percent of the prefire population. By comparison, Lawrence (1966) captured none on a large fire some 32 days after it was out (although tag returns indicated some did survive). Data provided by Cook (1959) indicate that 3 weeks after a large chaparral fire, the residual population was only about 2 percent in the grassland and 14 percent in brushland when compared to control populations. In smaller prescribed burns (up to 10 ha in size), residual populations have been as high as 50 percent of their controls (Spencer 1956, Tevis 1956, Fala 1975). Our data are of the same magnitude as those found in studies of large burns where immigration from adjacent unburned areas is not as extensive.

In the aspen-fir-spruce and jack pine communities combined, the population of the red-backed vole, an herbivore, was lowered more than that of the deer mouse or the masked shrew. This would be expected for a species whose primary food and cover had been eliminated by fire. In contrast, the higher postfire population of the masked shrew, an insectivore, was unexpected, because it seems that fire would reduce food and cover important to their survival in a manner similar to red-backed voles. However, the sample size was small and there is no literature to corroborate this observation. The population of the deer mouse, a granivore, was low on the aspen-fir-spruce burned area, only 8 percent of its control. In the jack pine community, however, their abundance on the burned area exceeded that of the control area. This can be explained by the postfire jack pine and black spruce seedfall data that estimated 68,000 viable seeds/ha in the aspen-fir-spruce burn and 484,000 viable seeds/ha in the jack pine burn .[1]

A severe reduction in herbivores and the invasion of granivores following fire has been reported (Tevis 1956, Cook 1959, Tester 1965, Ahlgren 1966, Sims and Buckner 1972, Krefting and Ahlgren 1974, Fala 1975). However, data provided by Ahlgren (1966), Sims and Buckner (1972), and Krefting and Ahlgren (1974) suggest that this will be transitory. Depending on outside population levels, red-backed vole populations should remain low and deer mouse populations should decline in the jack pine community until the end of the first or possibly second growing season when the ground vegetation recovers and begins to produce seed. Then, deer mice should increase and at the end of the third growing season red-backed voles should begin to increase. Habitat should remain more favorable for deer mice for about seven growing seasons, after which it should become more favorable for red-backed voles. The pattern in the aspen-fir-spruce community should be similar except the abundance of red-backed voles and deer mice should remain low until the end of the first or second growing season for deer mice and the third growing season for red-backed voles.

Because the Roy Lake Fire occurred in early fall, revegetation will not occur until the following spring. By this time, the lack of food and cover and winter mortality should reduce red-backed vole populations to even lower levels and they should remain low for several years. Thus, this species should not be a significant factor in the reforestation of any of the three communities, in spite of the high current population. Although the same may not be true for deer mice, the lack of vegetation, winter mortality, and the fact that reproductive activites for the year were complete should hold down their spring population. This would be important to natural reforestation of areas where seedfall was light. However, because seedfall in the jack pine and black spruce-jack pine communities was more than sufficient,

adequate moisture for germination and survival will probably control reforestation. In the aspen-fir-spruce community, where aspen vegetative reproduction is likely, deer mice will have little impact.

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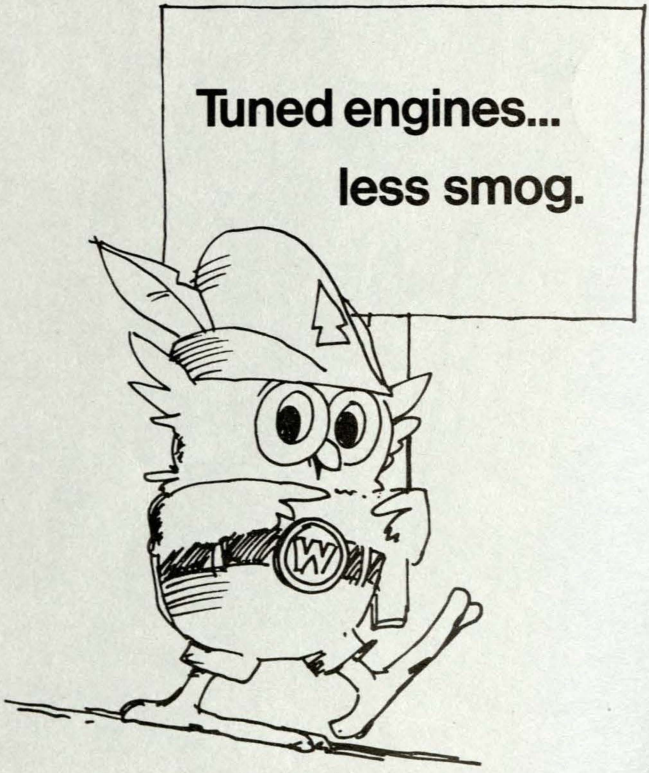
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